

Some theory...

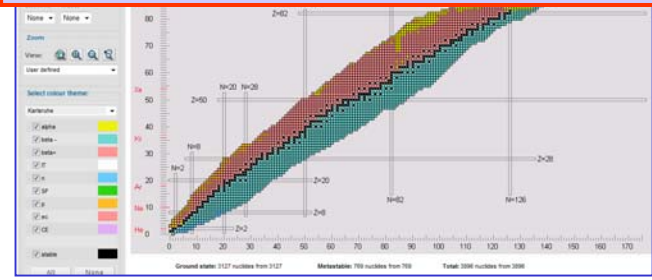
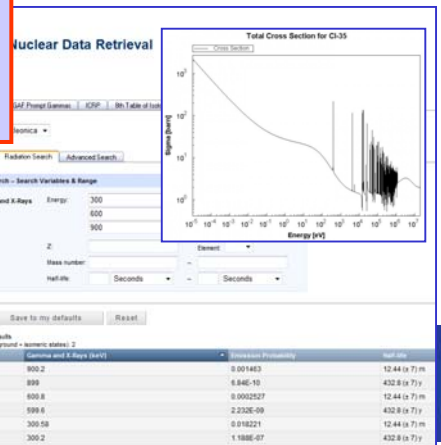
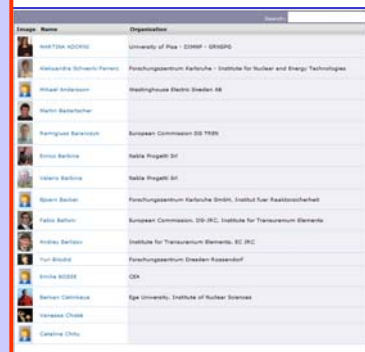
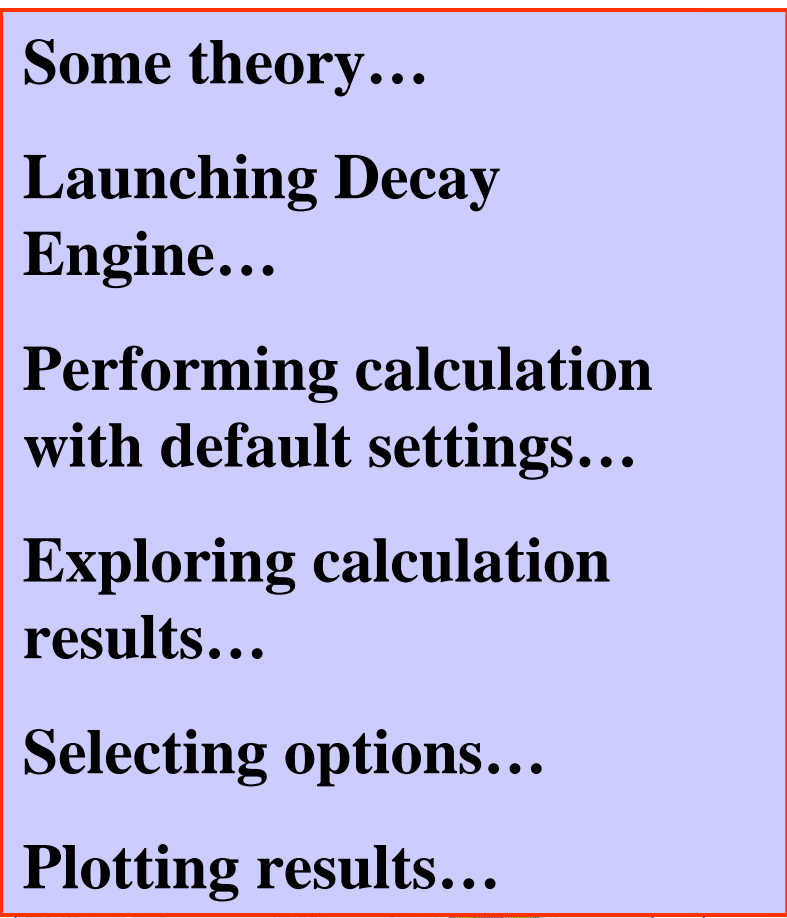
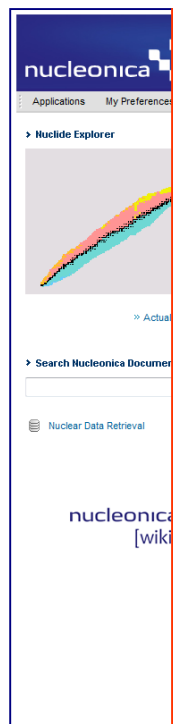
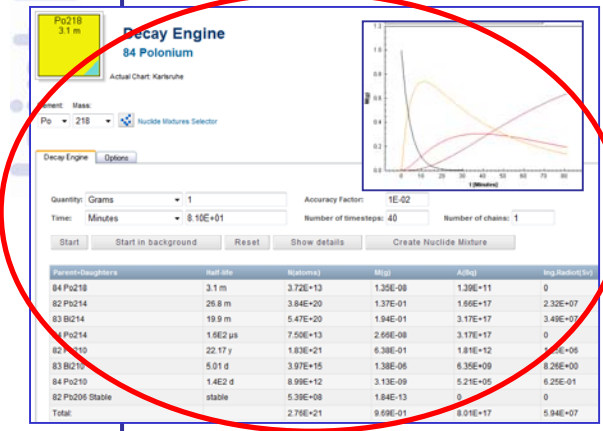
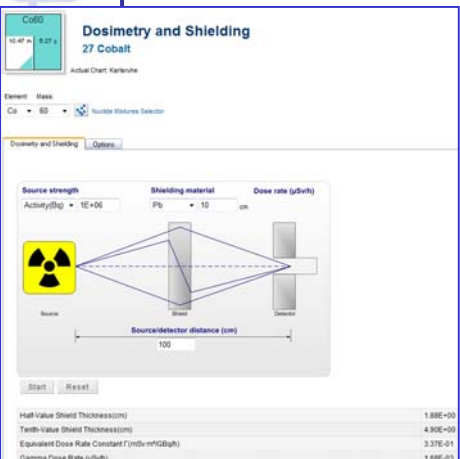
Launching Decay Engine...

Performing calculation with default settings...

Exploring calculation results...

Selecting options...

Plotting results...



Search returned 6 results
number of nuclides (ground + isomeric states): 2

Isotope	Half-life	Decay mode	Energy (keV)	Intensity (%)
80 Kr 151	900.2	β ⁻	0.001403	12.44 (α 71 m)
80 Ar 241	899	β ⁻	0.846-10	432.8 (α 71 m)
80 Kr 151	800.8	β ⁻	0.0002527	12.44 (α 71 m)
80 Ar 241	599.6	β ⁻	2.232E-09	432.8 (α 71 m)
80 Kr 151	300.58	β ⁻	0.018221	12.44 (α 71 m)
80 Ar 241	300.2	β ⁻	1.188E-07	432.8 (α 71 m)

Modern Alchemy: Discovery of transmutation, (Soddy 1901)

In 1901, twenty-four year-old chemist Frederick Soddy and Ernest Rutherford were attempting to identify a mysterious gas that wafted from samples of radioactive thorium oxide. They suspected that this gas—they called it an “emanation”—held a key to the recently discovered phenomenon of radioactivity. Soddy had passed the puzzling gas over a series of powerful chemical reagents, heated white-hot. When no reactions took place, he came to a startling realization. As he told his biographer many years later....

‘I remember quite well standing there transfixed as though stunned by the colossal import of the thing and blurting out- or so it seemed at the time: “Rutherford, this is transmutation: the thorium is disintegrating and transmuting itself into argon gas”. Rutherford’s reply was typically aware of more practical implications, “For Mike’s sake, Soddy, don’t call it *transmutation*. They’ll have our heads off as alchemists”

*quoted in *Pioneer*, pp 83-84

Frederic Soddy



Joseph Wright (1734-1797)



Simple radioactive decay..

Basic equation first identified by Rutherford

$$dQ/dt = -kQ \quad (1)$$

Q is the number of atoms, k is the decay constant
(probability per unit time that a nucleus will decay):

$$k = \ln 2 / \tau$$

where τ is the half-live. Solution of Eq.1...

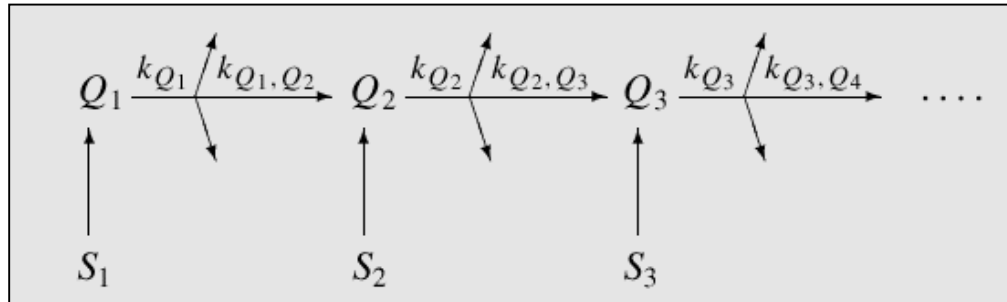
$$Q(t) = Q(0) e^{-kt} \quad \text{or} \quad Q(t) = Q(0) 2^{-t/\tau}$$

Activity..

$$A(t) = k Q(t)$$



Successive radioactive decay with branching and source terms



The differential equations governing the above processes:

$$\begin{aligned} dQ_1/dt &= S_1 - k_{Q_1} \cdot Q_1, \\ dQ_2/dt &= S_2 + k_{Q_1,Q_2} \cdot Q_1 - k_{Q_2} \cdot Q_2, \\ dQ_i/dt &= S_i + k_{Q_{i-1},Q_i} \cdot Q_{i-1} - k_{Q_i} \cdot Q_i, \\ dQ_n/dt &= S_n + k_{Q_{n-1},Q_n} \cdot Q_{n-1} - k_{Q_n} \cdot Q_i, \end{aligned}$$

Mr Bateman, *Solution of a system of differential equations, etc.* 423

The solution of a system of differential equations occurring in the theory of radio-active transformations. By H. BATEMAN, M.A., Trinity College.

[Read 21 February 1910.]

1. It has been shown by Prof. Rutherford * that the amounts of the primary substance and the different products in a given quantity of radio-active matter vary according to the system of differential equations,

$$\left. \begin{aligned} \frac{dP}{dt} &= -\lambda_1 P \\ \frac{dQ}{dt} &= \lambda_1 P - \lambda_2 Q \\ \frac{dR}{dt} &= \lambda_2 Q - \lambda_3 R \\ \frac{dT}{dt} &= \lambda_3 R - \lambda_4 T \\ &\dots\dots\dots \end{aligned} \right\} \dots\dots\dots (1).$$



H. Bateman

denote the number of atoms of the primary substance and the various products which are present at time t . He has worked out the various cases in which the products in addition to the primary substance, but as if the results may be extended to any case without much labour.

The straightforward method is unsymmetrical, and the results of the calculations are needed in cases which are being carried on in radio-activity, but it is worth while to publish a simple and direct method of obtaining the required formulae. We use a set of auxiliary quantities $p(x)$, $q(x)$, $r(x)$, $s(x)$, on a variable x and connected with the $P(t)$, $Q(t)$, $R(t)$, $T(t)$ by the equations,

$$p(x) = \int_0^\infty e^{-xt} P(t) dt, \quad q(x) = \int_0^\infty e^{-xt} Q(t) dt, \dots\dots (2).$$

It is easily seen that

$$\begin{aligned} \int_0^\infty e^{-xt} \frac{dP}{dt} dt &= -P(0) + x \int_0^\infty e^{-xt} P(t) dt \dots\dots\dots (3), \\ &= -P_0 + xp, \end{aligned}$$

* *Radio-activity*, 2nd edition, p. 582.

Exact solution:
$$Q_n(t) = \sum_{i=1}^{j=n} \left[\left(\prod_{j=1}^{j=n-1} k_{j,j+1} \right) \times \sum_{j=i}^{j=n} \left(\frac{Q_i(0) e^{-k_j t}}{\prod_{\substack{p=i \\ p \neq j}}^n (k_p - k_j)} + \frac{S_i (1 - e^{-k_j t})}{k_j \prod_{\substack{p=i \\ p \neq j}}^n (k_p - k_j)} \right) \right]$$

For $S_i = 0$:
$$Q_n(t) = \prod_{j=1}^{j=n-1} k_{j,j+1} \sum_{j=i}^{j=n} \frac{Q_i(0) e^{-k_j t}}{\prod_{\substack{p=i \\ p \neq j}}^n (k_p - k_j)}$$

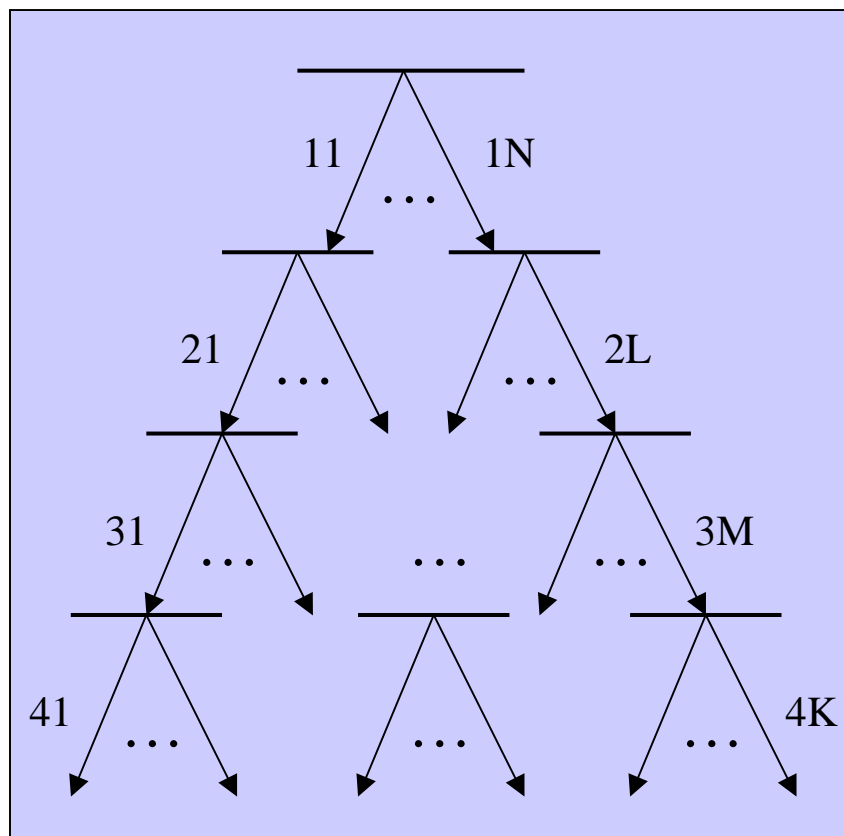
First few terms...

$$Q_1 = Q_1(0) e^{-k_1 t}$$

$$Q_2 = k_{1,2} \left\{ \frac{Q_1(0) e^{-k_1 t}}{k_2 - k_1} + \frac{Q_1(0) e^{-k_2 t}}{k_1 - k_2} \right\}$$

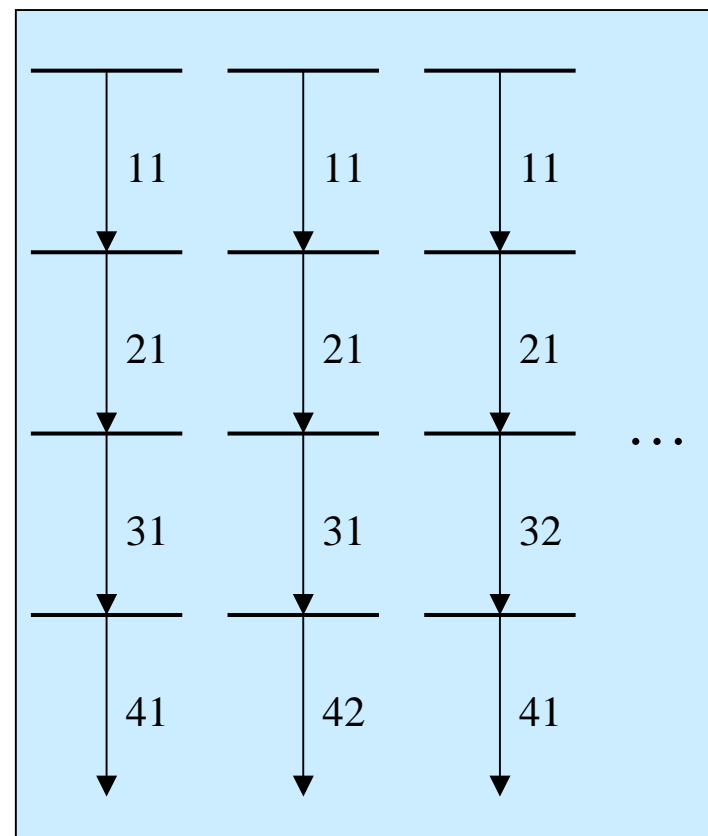
$$Q_3 = k_{1,2} k_{2,3} \left\{ \frac{Q_1(0) e^{-k_1 t}}{(k_2 - k_1)(k_3 - k_1)} + \frac{Q_1(0) e^{-k_2 t}}{(k_1 - k_2)(k_3 - k_2)} + \frac{Q_1(0) e^{-k_3 t}}{(k_1 - k_3)(k_2 - k_3)} \right\}$$

Decay Tree



Linear Chains

\Rightarrow

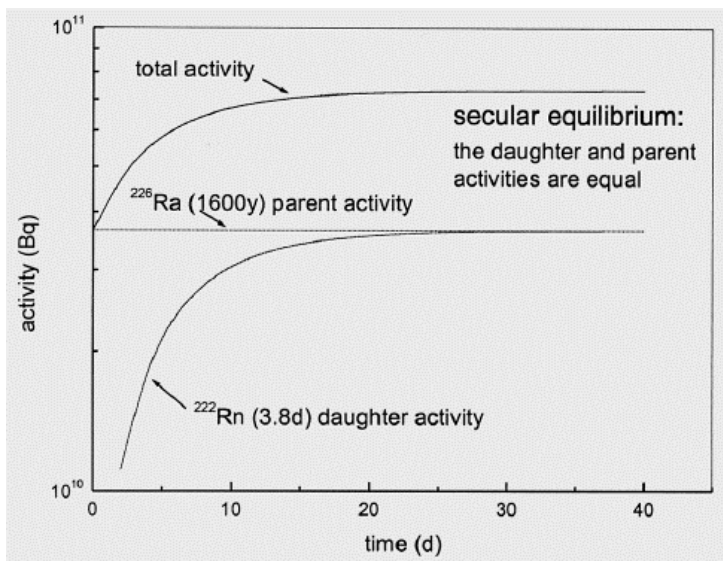


$$\text{Prod}_1 = \text{BR}_{11}\text{BR}_{21}\text{BR}_{31}\text{BR}_{41}$$

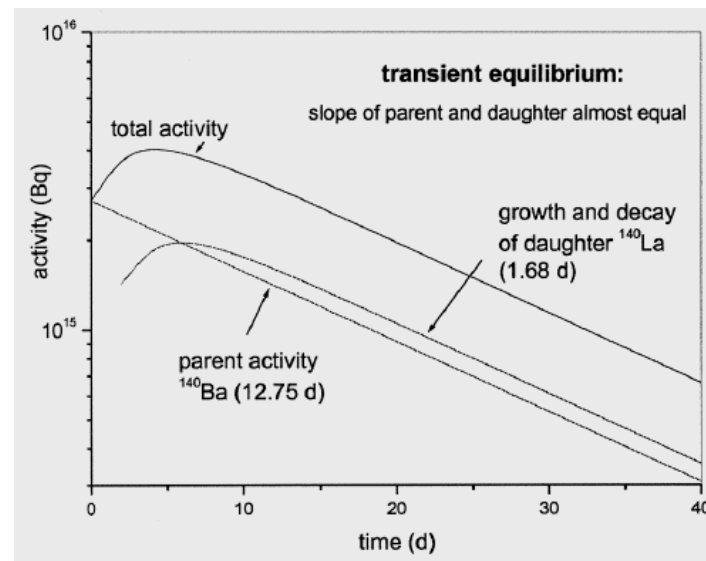


Decay Engine

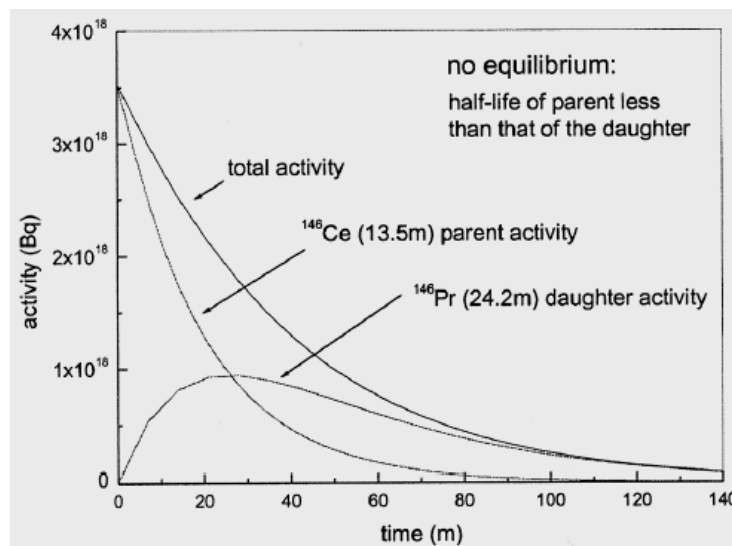
$$\tau_1 \gg \tau_2 : A_1 = A_2$$



$$\tau_1 > \tau_2 : A_2 = \tau_1 A_1 / (\tau_1 - \tau_2)$$



$$\tau_1 < \tau_2$$





Decay Engine



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Applications My Preferences Help New Alerts

Nuclide Explorer

Mass Activity Calculator

Decay Engine

Dosimetry and Shielding

Range and Stopping Power

webKORIGEN

Universal Nuclide Chart

Transport and Packaging

Nuclide Mixtures

Nucleonica Scripting

Library Creation

Extended Graph Module

Physical Constants

Nuclide Datasheet

Radiations

Fission Yields

Nuclear Data Retrieval

Nuclear News

Conference Calendar

Application Centre

- » Mass Activity Calculator
- » **Decay Engine**
- » Dosimetry & Shielding
- » Range & Stopping Power
- » webKORIGEN
- » Universal Nuclide Chart
- » Transport & Packaging
- » Nuclide mixtures
- » Nucleonica Scripting
- » Library creation for 3rd party software
- » Radiological Dispersion Module
- » Extended Graph Module

Data Centre

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- » Nuclide Datasheets
- » Nuclide Derived Data
- » Average Cross Sections
- » Radiations
- » Prompt Gamma
- » Fission Yields

Knowledge Centre

- » Nuclear News
- » Reading room
- » Useful Weblinks
- » Ask An Expert
- » Element Information
- » Conference Calendar

Welcome, Andrey

Edit Preferences
MyCommunity Portal

My Last Nuclides

- 92 U235
- 43 Tc90
- 52 Te118
- 34 Se81 m
- 73 Ta155

My Nuclide Mixtures

- Transuramics in 1 ton Spent Fuel (4.2% enriched, %50GyVd/t, 6 years cooling)
- Cs137+Ba137m
- U232+Co60
- Test_Source_1

My Sources

No sources selected yet

My Messages

- Maintenance Work
- Maintenance Work
- Maintenance Work
- NAMLS-9 International Conference on Nuclear Analytical Methods in the Life Sciences
- Request for photos of non-stable elements

User Alerts

To launch the Decay Engine

click on Decay Engine in the Application Center list.....

or

choose Decay Engine from the Applications dropdown list....



Decay Engine



Joint Research Centre

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Views Applications My Preferences Help New Alerts

z
N

Select

Element: Mass:
Po 218

Zoom

View: 5

Select colour theme:
Karlsruhe

☒ alpha
☒ beta -
☒ beta +
☒ IT
☒ n
☒ SF
☒ p
☒ ec
☒ CE

☒ stable

All None

Background

Rn216 45 μ s	Rn217 540 μ s	Rn218 35 ms	Rn219 3.96 s	Rn220 55.8 s	Rn221 25 m	Rn222 3.82 d
At215 100 μ s	At216 300 μ s	At217 32.3 ms	At218 1.5 s	At219 54 s	At220 3.71 m	At221 2.3 m
Po214 1.6E2 μ s	Po215 1.78 ms	Po216 150 ms	Po217 1.47 s	Po218 3.1 m	Po219 2 m	Po220 40 s
Bi213 45.59 m	Bi214 19.9 m	Bi215 36.9 s 7.4 m	Bi216 2.17 m	Bi217 1.84 s		
Pb212 10.64 h	Pb213 10.2 m	Pb214 26.8 m	Pb215 36 s			

130 131 132 133 134 135 136

Ground state: 3127 nuclides from 3127 Metastable: 769 nuclides from 769 Total: 3896 nuclides from 3896

Highlight daughters
Show decay chain
Reference Data
Element Information
Decay Engine
Dosimetry & Shielding
Get image
Remove red border
Cancel

To launch the Decay Engine

select nuclide of interest in the Nuclide Explorer page.....

then

click right mouse button over it

and

choose Decay Engine from the list, which will appear


.....



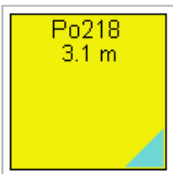


Decay Engine

Joint Research Centre



Applications My Preferences Print




Po218
3.1 m

Decay Engine

84 Polonium

Actual Chart: Karlsruhe

Element: Mass: Po 218  Nuclide Mixtures Selector

Decay Engine Options


Quantity: Grams Time: Minutes

Start Start in background

Type of graph: Numbers

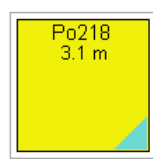
Version 1.0.0000.0090

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Applications My Preferences Print Help **New Alerts**



Decay Engine

84 Polonium

Actual Chart: Karlsruhe

Element: Mass: Po 218  Nuclide Mixtures Selector

Decay Engine Options

Quantity: Grams 1 Time: Minutes 3.10E+01

Start Start in background Reset

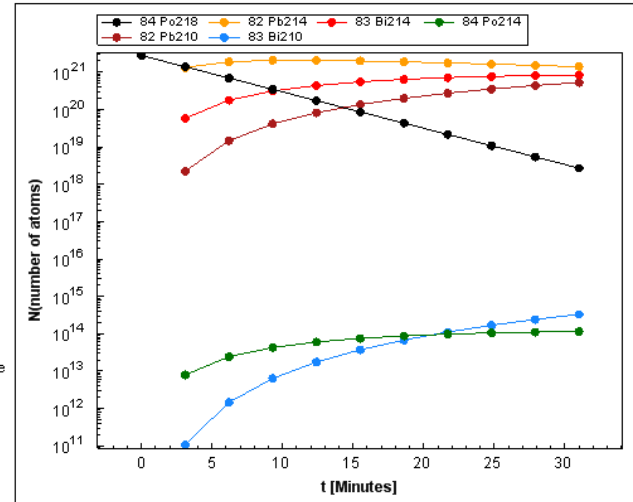
Parent+Daughters	Half-life	BR
84 Po218	3.1 m	0.99981; 1.9
82 Pb214	26.8 m	1
83 Bi214	19.9 m	0.99979; 2.1
84 Po214	1.6E2 μ s	1
82 Pb210	22.17 y	1; 1.90E-08
83 Bi210	5.01 d	0.999999; 1
84 Po210	1.4E2 d	1
82 Pb206 Stable	stable	
Total:		

Download ☒ Excel ☐ CSV Separator: Semicolon

Type of graph: Numbers

☒ 84 Po218
☒ 82 Pb214
☒ 83 Bi214
☒ 84 Po214
☒ 82 Pb210
☒ 83 Bi210
☐ 84 Po210
☐ 82 Pb206 Stable
☐ Total

Update



Show Graph Settings
Print
Download

Start a calculation using default values....



Decay Engine

Element Info in
Nucleonica
wiki

Nuclide
selection tools

Mass-activity
calculator

Set the time

Select the value
to be plotted on
a graph

Set the number of timesteps. To
plot a graph up to 40 timesteps
can be used

Set the accuracy of the calculation. Default
value 1E-2 gives at least the main
chain. Min. **Zero value gives all chains!**

Number of chains
with Accuracy
Factor > 1E-2



Decay Engine



Joint Research Centre

Po218
3.1 m

Decay Engine 84 Polonium

Actual Chart: Karlsruhe

1 84 Po218 2.71E+18 82 Pb214 1.40E+21 83 Bi214 8.35E+20 84 Po214 1.15E+14 82 Pb210 5.25E+20 83 Bi210 3.28E+14 84 Po210 2.39E+11 82 Pb206 Stable 3.21E+06 Prod = 1.00E+00 Total = 2.76E+21	6 84 Po218 2.71E+18 85 At218 4.19E+12 86 Rn218 9.77E+07 84 Po214 4.57E+05 82 Pb210 5.24E+14 83 Bi210 8.25E+08 84 Po210 1.08E+06 82 Pb206 Stable 3.39E+01 Prod = 1.90E-07 Total = 2.71E+18
2 84 Po218 2.71E+18 82 Pb214 1.40E+21 83 Bi214 8.35E+20 81 Tl210 1.12E+16 82 Pb210 9.90E+16 83 Bi210 5.79E+10 84 Po210 3.98E+07 82 Pb206 Stable 4.23E+02 Prod = 2.10E-04 Total = 2.24E+21	7 84 Po218 2.71E+18 85 At218 4.19E+12 83 Bi214 2.11E+17 81 Tl210 3.09E+12 82 Pb210 6.26E+13 83 Bi210 5.40E+07 84 Po210 4.82E+04 82 Pb206 Stable 1.11E+00 Prod = 3.99E-08 Total = 2.92E+18
3 84 Po218 2.71E+18 85 At218 4.19E+12 83 Bi214 2.11E+17 84 Po214 2.89E+10 82 Pb210 3.13E+17 83 Bi210 2.90E+11 84 Po210 2.76E+08 82 Pb206 Stable 6.41E+03 Prod = 1.90E-04 Total = 3.23E+18	8 84 Po218 2.71E+18 82 Pb214 1.40E+21 83 Bi214 8.35E+20 84 Po214 1.15E+14 82 Pb210 5.25E+20 80 Hg206 3.63E+06 81 Tl206 1.19E+06 82 Pb206 Stable 1.42E+06 Prod = 1.90E-08 Total = 2.76E+21
4 84 Po218 2.71E+18 82 Pb214 1.40E+21 83 Bi214 8.35E+20 82 Pb210 1.57E+16 83 Bi210 9.85E+09 84 Po210 7.17E+06 82 Pb206 Stable 1.17E+02 Prod = 3.00E-05 Total = 2.24E+21	9 84 Po218 2.71E+18 82 Pb214 1.40E+21 83 Bi214 8.35E+20 81 Tl210 1.12E+16 82 Pb209 6.69E+12 83 Bi209 2.36E+11 81 Tl205 Stable 0.00E+00 Prod = 1.47E-08 Total = 2.24E+21
5 84 Po218 2.71E+18 82 Pb214 1.40E+21 83 Bi214 8.35E+20 84 Po214 1.15E+14 82 Pb210 5.25E+20 83 Bi210 3.28E+14 81 Tl206 1.50E+05 82 Pb206 Stable 1.65E+05 Prod = 1.32E-06 Total = 2.76E+21	10 84 Po218 2.71E+18 85 At218 4.19E+12 83 Bi214 2.11E+17 82 Pb210 9.39E+12 83 Bi210 8.71E+06 84 Po210 8.28E+03 82 Pb206 Stable 0.00E+00 Prod = 5.69E-09 Total = 2.92E+18

Accuracy Factor: 0
Number of timesteps: 10
Number of chains: 23

Reset Show Details Create Nuclide Mixture

	Decay	N(atoms)	M(g)	A(Bq)
		2.76E+21	9.78E-01	1.58E+18
	β^-	1.40E+21	4.97E-01	6.03E+17
99979; 2.10E-04; 3.00E-05	β^- ; α ; β^- ; α	8.36E+20	2.97E-01	4.85E+17
	α	1.15E+14	4.07E-08	4.85E+17
99981; 1.90E-04	α ; β^-	2.71E+18	9.81E-04	1.01E+16
99993; 7.00E-05	β^- ; β^- ; n	1.12E+16	3.91E-06	9.97E+13
999; 1.00E-03	α ; β^-	4.19E+12	1.52E-09	1.94E+12
1.90E-08	β^- ; α	5.25E+20	1.83E-01	5.20E+11
	α	9.77E+07	3.54E-14	1.94E+09
999999; 1.32E-06	β^- ; α	3.29E+14	1.15E-07	5.26E+08
	β^-	6.70E+12	2.32E-09	3.96E+08
	α	2.39E+11	8.35E-11	1.39E+04
	β^-	3.64E+06	1.24E-15	5.16E+03
	β^-	1.34E+06	4.58E-16	3.68E+03
	α	2.36E+11	8.21E-11	2.73E-16
		4.80E+06	1.64E-15	0
		0	0	0

Click on the column title to arrange the data in ascending /descending order on the parameter chosen





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Applications My Preferences Print Help **New Alerts**

Po218
3.1 m

Decay Engine

84 Polonium

Actual Chart: Karlsruhe

Element: Mass:

Po 218 Nuclide Mixtures Selector

Decay Engine Options

Decay Engine Settings

<input checked="" type="checkbox"/> Halflives	<input checked="" type="checkbox"/> Masses	<input type="checkbox"/> Gamma Emission Rate	<input type="checkbox"/> Isotopic Power (α)
<input checked="" type="checkbox"/> Branching Ratio	<input checked="" type="checkbox"/> Activities	<input type="checkbox"/> Spontaneous Fission Rate	<input type="checkbox"/> Isotopic Power ($\alpha+\beta$)
<input checked="" type="checkbox"/> Decay Mode	<input type="checkbox"/> Activities (alpha)	<input type="checkbox"/> Ingestion Radiotoxicity	<input type="checkbox"/> Isotopic Power ($\alpha+\beta+\gamma$)
<input checked="" type="checkbox"/> Numbers	<input type="checkbox"/> Activities (beta)	<input type="checkbox"/> Inhalation Radiotoxicity	

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Radiotoxicity (Sv) = Activity \cdot $e(50)$, where $e(50)$ - effective dose coefficient, which accounts for radiation and tissue weighting factors, metabolic and biokinetic information.

the heat generated per unit time by the decay radiations (W)



Decay Engine

Type of graph: Activities

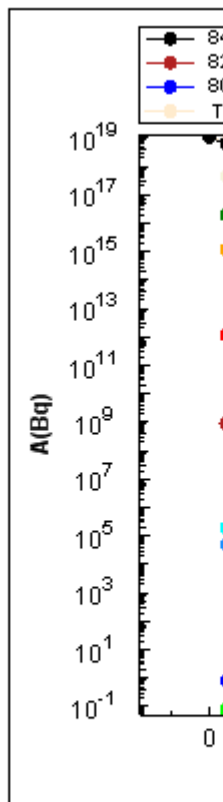
- ☒ 84 Po218
- ☒ 85 At218
- ☒ 86 Rn218
- ☒ 84 Po214
- ☒ 82 Pb210
- ☒ 83 Bi210
- ☒ 84 Po210
- ☐ 82 Pb206 Stable
- ☒ 81 Tl206
- ☒ 80 Hg206
- ☐ 83 Bi214
- ☒ 81 Tl210
- ☒ 82 Pb209
- ☐ 83 Bi209
- ☐ 81 Tl205 Stable
- ☒ 82 Pb214
- ☒ Total:

Update

Show Graph Settings

Print

Download



General Graph Settings

Image Width: 500 Image Height: 400

Line Style: Line with Symbols

☒ Border
☒ Graph Border
☒ Show Legend

Titles

Graph Title:

Category (X): t [Days]

Value (Y): A(Bq)

Axes

Axis	Type	Min	Max
Y	<input type="radio"/> linear	0.2904	1.03E+19
	<input checked="" type="radio"/> log	<input checked="" type="checkbox"/> Auto scale Y	
X	<input checked="" type="radio"/> linear	0	0.0215
	<input type="radio"/> log	<input checked="" type="checkbox"/> Auto scale X	

Gridlines and Ticks

Category (X) Axis	Value (Y) Axis
<input type="checkbox"/> Major Gridlines	<input type="checkbox"/> Major Gridlines
<input type="checkbox"/> Minor Gridlines	<input type="checkbox"/> Minor Gridlines

Ticks Location: ☐ Outside scale ☒ Inside scale ☐ Through scale

Tick Steps:

X Axis: Major Step Minor Step

☒ Auto set steps

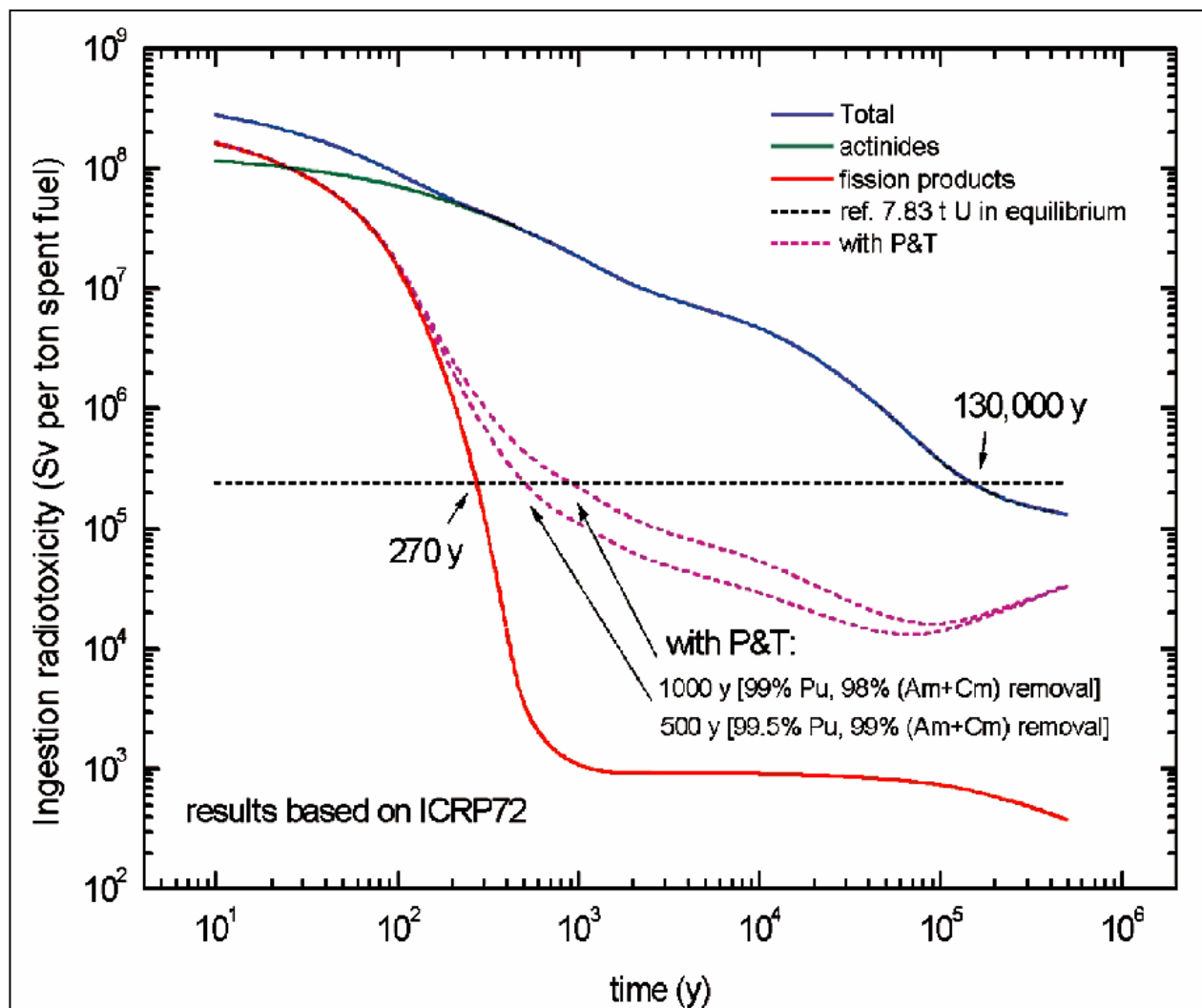
Y Axis: Major Step Minor Step

☒ Auto set steps

Redraw Graph



Decay Engine



nucleonica [wiki]
Help Extended Graphics Module

Contents [view]
1.1 Introduction
1.2 Simple Example
1.2.1 Straight line
1.2.2 Curve
1.2.3 The Configuration File
1.3 Nucleonica
1.4 Large Data Files
1.5 Geiger-Müller Law

Nucleonica webGraphics

Introduction
The main advantages of the Nucleonica webGraphics can be summarised as follows:
• No need to buy expensive commercial software
• Easy to use
• Delivers publication quality scientific graphs
• Variety of formats available (gif, jpg, emf, eps, pdf, png)
• Graphics configuration can be stored for future use
• Available at any time from any location
• Under constant further development

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Applications My Preferences Help New Alerts

> Nuclide Explorer



> Application Centre

- Mass Activity Calculator
- Decay Engine
- Dosimetry & Shielding
- Range & Stopping Power
- webKORIGEN
- Universal Nuclide Chart
- Transport & Packaging
- Nuclide mixtures
- Nucleonica Scripting
- Library creation for 3rd party software
- Radiological Dispersion Module

Welcome, Joe
Edit Preferences Administration MyCommunity Portal

> My Last Nuclides

- 82 Pb210
- 88 Ra226
- 55 Cs137
- 40 Zr95
- 84 Po210

> My Nuclide Mixtures

- Ra-226 + daughters (1g at 1y)
- Decay Engine Result

nucleonica ... web driven nuclear science

Applications My Preferences Help New Alerts

> Nuclide Explorer

> Application Centre

Welcome, Joe
Edit Preferences Administration MyCommunity Portal

> My Last Nuclides

- 82 Pb210
- 88 Ra226
- 55 Cs137
- 40 Zr95
- 84 Po210

> My Nuclide Mixtures

- Ra-226 + daughters (1g at 1y)
- Decay Engine Result

Thank you for your attention...

> Prompt Gamma
> Fission Yields

NAMLS-9 International Conference on Nuclear Analytical Methods in the Life Sciences
Request for photos of non-stable elements

> Knowledge Centre

> Nuclear News
> Reading Room
> Useful Weblinks
> Ask An Expert

View

Name	Organisation
Andreas Schmitt	University of Pisa - INFN - INFN
Andreas Schmitt	Forschungszentrum Karlsruhe - Institute for Nuclear and Energy Technology
Andreas Schmitt	Wuppertal Electric Sweden AB
Andreas Schmitt	European Commission DG-TRIS
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Dosimetry and Shielding
27 Cobalt

Actual Chart Karlsruhe

Source strength
Activity [Bq] = 1E+06

Shielding material
Pb = 10 cm

Dose rate [μSv/h]

Source-detector distance [cm]
100

Start ... Reset

Half-Value Shield Thicknesses
Tenth-Value Shield Thicknesses
Equivalent Dose Rate Constant Γ (mSv·m²/Bq·h)
Gamma Dose Rate [μSv/h]

1.89E+09
4.90E+09
3.37E-01
1.68E-03

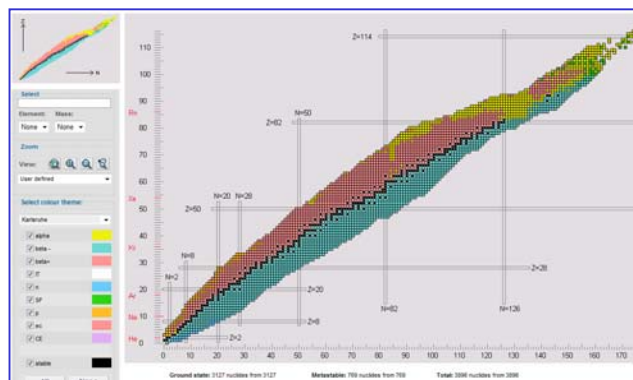
Decay Engine
84 Polonium

Actual Chart Karlsruhe

Quantity: Grams 1
Time: Minutes 8.10E+01
Accuracy Factor: 1E-02
Number of timesteps: 40
Number of chains: 1

Start Start in background Reset Show details Create Nuclide Mixture

Parent-Daughters	Half-life (minutes)	λ (1/min)	λ (1/s)	log(Radiation)
84 Po218	3.1 m	3.72E+13	1.35E-08	1.39E+11
82 Pb214	26.8 m	3.84E+10	1.37E-01	1.66E+17
83 Bi214	19.9 m	5.47E+10	1.94E-01	3.17E+17
84 Po214	1.662 μs	7.50E+13	2.66E-08	3.17E+17
82 Pb210	22.17 y	1.83E+21	6.38E-01	1.81E+12
83 Bi210	5.01 d	3.97E+15	1.38E-06	6.35E+09
84 Po210	1.462 d	8.99E+12	3.13E-09	5.21E+05
82 Pb206 Stable	stable	1.84E-13	0	0
Total	2.76E+21	9.69E-01	9.91E-17	5.94E+07



Nuclear Data Retrieval

Total Cross Section for Cl-35

Search returned results
number of nuclides (ground + isomers) = 2

Isotope	Element	Mass Number	Half-life	Decay Mode	Energy [keV]	Intensity [%]
35Cl	Chlorine	35	3.08E+02	β ⁻	0.01463	100.0
36Cl	Chlorine	36	3.08E+02	β ⁻	0.01463	100.0